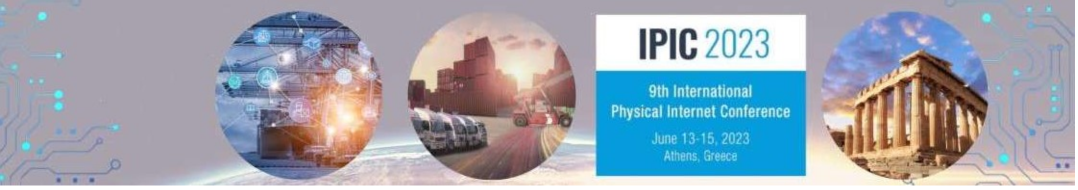

Prerequisites for Data Sharing and Realizing Off-peak Deliveries

Annette Hultåker[1], Magnus Blinge[1], Ibrahim Jabarkhel[2], Minna Sandberg[2]
1. Scania CV, Södertälje, Sweden
2. LogTrade Technology AB, Malmö, Sweden
Corresponding author: annette.hultaker@scania.com

Abstract: *Off-Peak is an efficient way to transport goods to dense urban environments where congestion and lack of space have a major impact on the productivity of the delivery. Battery Electric Vehicles are quiet and have opened the possibilities for freight deliveries in cities at night. One challenge is that the deliveries must be possible to make without having staff at night to receive the delivery. In the HITS (Sustainable & Integrated Urban Transport System) project, we have accomplished a successful test and proven that unmanned off-peak deliveries can start to be implemented for many applications and can reduce delivery time by 30 percent. One-time encrypted digital smart lock solutions enable the right goods, from the right truck, at the right time, in the right location to get access to, e.g., restaurants after closing hours. In order for off-peak deliveries in a "Physical Internet"-setup to work, data needs to be shared between the actors. One part of the project has studied the prerequisites for data sharing to enable a trustful collaboration between different stakeholders in general. Important factors are the willingness to apply data-driven decision making and trust between the different actors within a supply chain.*

Keywords: *off-peak deliveries; urban freight; freight efficiency; night-time distribution; unmanned delivery; connected goods, data sharing*

Conference Topic(s): *Distributed intelligence last mile & city logistics*

Physical Internet Roadmap*: System of Logistics Networks,*

1 Introduction

The logistics system in urban environments is stressed. Freight forwarders are forced to meet customers' increased expectations for speed and flexibility by deploying more vehicles, each with a smaller load capacity. This development further amplifies the difficult challenges of congestion and sustainability in cities and it often leads to unnecessarily long lead times and imprecise deliveries. HITS project is a Stockholm-based multi-stakeholder collaboration with the mission to develop transport-efficient solutions that provide cleaner and safer cities.

Off Peak is an efficient way to transport goods to dense urban environments where congestion and lack of space have a major impact on the productivity of the delivery. Battery Electric Vehicles (BEV) are quiet and have opened the possibilities for freight deliveries in cities at night. It also offers an opportunity for transport companies to use the vehicles 24/7 at lower total cost. This also means that demand for BEVs may increase.

One challenge is that the deliveries must be possible to make without having staff at night to receive the delivery. In the HITS project, we have proven that unmanned off-peak solutions can be implemented for many applications and thereby reducing delivery times by 30 percent. One-time encrypted digital smart lock solutions enable the right goods, from the right truck, at the right time, in the right location to get access to e.g. restaurants after closing hours.

In order for off-peak deliveries on a "Physical Internet"-setup to work, data need to be shared between the actors. One part of the HITS project has studied the prerequisites for data sharing to enable a trustful collaboration between different stakeholders. The prerequisites for data sharing are in this study applied in unmanned off-peak deliveries, with the purpose to evaluate strengths and challenges of the current solution and to identify needs for further investigations.

2 Methodology and Research Process

In the literature on urban logistics, off-peak deliveries are often mentioned as a promising concept with substantial potential for reducing environmental impacts, congestion and costs. However, there are some conflicting goals that must be addressed. Verlinde (2015) exemplifies, e.g., noise pollution at night, increased labour costs, and liability issues as areas that need to be addressed in which conflicting interests of the stakeholders involved must be addressed and balanced. The author further points out that the negative effects might not easily be overcome. The conflicting interests of different stakeholders in the city, i.e., trade and industry, society, and public policy-makers must be involved in this process.

The design thinking process, involving workshops and stakeholder engagement, has been a very efficient method in structuring problem framing. Unlike traditional linear methods for problem-solving, Design Thinking is an iterative and insight-driven process where testing and pivoting from the original ideas to new ideas, are fundamental. It is a process designed to help us shift focus from HOW to solve something to rather understanding WHAT problem to solve.

After the initial workshops in the design thinking process with the aim of identifying and understanding the stakeholders' needs and challenges, a demonstration of unmanned off-peak deliveries to 4 restaurants in the shipper HAVI logistics system was carried out in the centre of Stockholm City.

2.1 Design thinking

Design Thinking (Stickdorn M & Schneider J, 2012) is a people-centred approach to innovation that, with the help of design methodology, ensures that the right customer value is met. Design Thinking uses design as a process to understanding and integrating people's needs, technology opportunities and goals and requirements for successful business value. By dividing the work into the phases Empathize, Define, Ideate, Prototype and Test in an iterative process, one focuses on the solution of the right problems, enables innovation, and ensures the value and relevance of the solutions that are developed. By working in a solution-oriented and agile way, the design process of tests/prototypes (e.g., "proof of concepts") close to customers helps the working group to understand customer values and quickly gather insights from operations and actual situations.

As Design Thinking is often used to solve complex problems, the design process can also be used to drive the transformation of businesses and organisations. The goal is still to create customer value, but new customer behaviour and the solutions may force the organisations to act differently. The design in that case delivers results by changing organizational behaviours, which in turn change customer behaviours.

2.2 Literature review - data sharing

The overview on data sharing presented in section 3 is mainly based on literature reviews, where not stated otherwise. A broad literature search was conducted in several libraries, incl. Google scholar, IEEE Xplore, ScienceDirect, and SCOPUS. The term "data sharing" was combined with different versions of "eco-system", "mobility" and "transport". Due to the rapid development within this field, mainly articles published in the last ten years have been considered. Web-searches have also been conducted, with similar search terms, to catch commercial trends that might not yet be published in scientific papers. The work presented here does not intend to give a full overview of this field, but rather to extract relevant material within this area.

2.3 Practical input - data sharing

The synthesis of relevant factors for data sharing is partly based on the author's (A. Hultåker's) almost 15 years of practical data sharing between departments within the automotive manufacturer company Scania. Much of that work has been conducted in ways similar to Design Thinking. The results are either undocumented, or cannot be shared in detail outside of Scania for confidential reasons.

3 Data sharing

Today, much of the collaboration between transport actors relies on digital data sharing, such as purchase orders or transportation orders. The recent boost in e-commerce has further increased these types of digital collaboration. Still, much of the data sharing covers only the bare minimum to keep the business going, and sometimes specific actors are left out of the sharing. Data sharing, data load, and data quality has become even more crucial as an increasing number of services are automated, for example by applying artificial intelligence. This creates advantages both from a system and unit perspective, but can also create disadvantages for those who are not included in the data sharing.

3.1 Research and regulations on data sharing

Research on data sharing is a fairly new field (Deloitte et al., 2018). And the same goes for regulations and policy making concerning data sharing and data usage. The rapid digitalisation in the last 10-15 years has been a major driving factor, and further spurred by growing e-commerce during the Covid-pandemics (World Economic Forum, 2021). During this period, the EU authorities have been striving to regulate the field to ensure customer privacy, fair competition, and yet a competitive data market through e.g. the General Data Protection Regulation (GDPR, 2016), the Open Data directive (2019) and the up-coming Data Act (EU Commission, 2022).

Most of the research so far has been done on open data sharing, often related to governmental data (Barbossa et al., 2014, and Ubaldi, 2013) and, for example, within the domains of transportation (Karpenko et al., 2018) or energy (Diran et al., 2020). The Open Data Institute (2023) gives a good overview of different types of data access. This work mainly deals with restricted data sharing. The actors and use cases that HITS have looked at are mainly group-based or named access, of various sizes, and provided on commercial grounds or by a governmental organisation.

3.2 Barriers for data sharing

It is important to understand what barriers exist against data sharing in order to determine which mechanisms that need be in place for it to work. Barriers might be perceived or real. IDC (2017) has identified three classes of barriers:

- **Cultural and organizational barriers:** e.g. no perceived potential benefits, lack of trust, fear of competition

- **Legal and regulatory barriers:** e.g. restrictions on data location, restrictions/ uncertainty about lawful grounds to use or share data, uncertainty about data ownership and data access
- **Technical and operational barriers:** e.g. lack of data interoperability, lack of standards, high costs of data curation to adapt it for sharing

As is clear from the listed barriers above, there is no individual factor hindering data sharing. However, some barriers can probably be explained by the fact that this field is rather new and thus undergoing changes, still setting standards as well as best practices, deciding on policies and regulations. At the same time, the closely related areas of software and technical platforms also undergo rapid development.

3.3 Data sharing eco-systems

To enable the potential benefits of sharing data, the barriers listed above need to be overcome. As there are a multitude of barriers, the solutions must fit together. An emerging view is that data sharing in eco-systems will evolve, where the different parts work in union. Nischak et al. (2017) states that three components are essential for any digital business ecosystem: value exchange, resources and actors.

Olivera et al. (2019) as well as Runeson et al.(2021) provide extensive overviews of the data sharing eco-system, both their definition and their development, although mainly concerning open data. Here the compiled definition by Runeson et al. (2021) is used to describe the data sharing eco-system as a complex socio-technical network consisting of two major components:

- A community of actors, which base their relations to each other on a common interest (Zuiderwijk et al., 2014)
- Supported by an underpinning technological platform (Jansen, 2020)

A data sharing eco-system is further something that enables the actors to:

- Process the data (Oliveira et al., 2019)
- Create value, foster innovation, or support new businesses (Oliveira et al., 2019)
- Collaborate on the data and boundary resources (Jansen, 2020)

3.4 Factors required for fully functional data sharing

The consultancy company Everis (2018) has, on behalf of the EU Commission, presented a thorough investigation on data sharing between companies in Europe and concludes that there are five key features of a thriving data-driven economy; **datasets, trust, infrastructure, security, and skills**. The authors argue that these are necessary factors also for establishing and maintaining functional data sharing between individual actors in networks. They are thus not just needed on an overall economic level, but needed for each data sharing initiative.

However, for individual cases of data sharing, there are three more factors that we also deem necessary; **business value, regulatory foundation, and meta data**.

Business value is needed for any healthy business relationship. Without a clear incentive for business, it will be hard to justify or engage in data sharing (Nischak et al. 2017). Although it might not necessarily be needed for a governmental data sharing initiative, it might bring about other values (Martens, 2020) such as co-loaded deliveries to pre-schools, thus increasing safety and reducing pollution as demonstrated by other partners in the HITS project (Södertörnskommunerna, 2023).

The importance of regulatory foundation is obvious when one considers the amount of regulations and policies in this field that the European commission and other legislative bodies have put forward during the last 10 years. Uncertainty regarding GDPR compliance is very common when e.g. position data from connected vehicles is discussed. Needless to say, any lasting business relationship needs to abide by the laws. Andersson (2022) elaborates in the report *Regulations for data sharing in city logistics: current situation analysis* on e.g. how companies can set up individual agreements regarding data sharing as grounds for data exchange.

Finally, meta data is usually overlooked in this context. The main reason for this is that most studies are done from the perspective of the data supplier, or from the perspective of the intermediate tech platform perspective. There seems to be very few studies done from the perspective of data users. Meta data issues are often addressed initially, simply by describing the general content and context of the data. However, most IT systems will sooner or later contain anomaly data and change both content and context over time. It is then crucial that the down-stream data receivers are also informed about any changes.

Reflecting on the barriers for data sharing presented in 3.2, one can see that the factors presented here correspond well to the barriers.

The eight factors can be said to form a data sharing eco-system, as defined in 3.3. Where the common interest of the actors is realised through finding business value, having a solid regulatory foundation, trust, and maintaining security. Runeson et al. (2021) points out the need for an underlying technical platform. In reality, when multiple actors are involved, there are usually several different platforms involved, between which data are transferred in some manner, today often via API:s (Application Programming Interface) as well as additional technical tools to process the data. API:s has the further advantage of establishing a sort of data contract, thus establishing the content and forms for the data, solving the meta data issue as well.

Usually all eight factors are needed. However, which factors are more or less important vary depending on the use case. Although the three factors, data, business value, and regulatory foundation, play a specific role as a starting point for any data sharing.

There is also an interdependence between the factors. For example an increased security level might take the edge off a potential distrust situation. It should be noted that infrastructure, security, and skills go very much hand-in-hand, although skills can also refer to curation of data and skills in solving the legal grounds for data sharing.

Some of the factors have to do with the internal culture of a company, e.g., trust, while some of the factors, most notably infrastructure, security, and skills can be obtained from external partners.

Finally, established data sharing has a potential to bring about new or added services for the actors, ranging from everyday tasks such as planning of staff, facilitating detection of deviations, to more advanced services such as improved route planning. In HITS we have demonstrated that off-peak deliveries are enabled through data sharing between the involved actors, and that the business venture can be further fine-tuned by analysing the obtained data.

4 Off-Peak

With the introduction of electric distribution vehicles, the problem with noise from vehicles in urban environments practically disappears and if the transport companies can shift to off-peak distribution, the transport efficiency and cost can be reduced at the same time as congestion at peak hours can be eased. Previous studies have shown that off-peak solutions can reduce the delivery time by at least 30 percent and increase the delivery precision (on-time) to almost 100 percent (Sanchez-Diaz I, Georen P & Brolinson M, 2017) (Holguín-Veras, J Marquis, R., & Brom, M., 2012).

However, although the concept is very promising, using electric distribution vehicles off-peak for deliveries does not solve all problems. Many challenges still need to be addressed, e.g., silent handling of material, safety issues and finding values and incentives for all involved stakeholders. Having personnel to receive goods at night is an unacceptably high cost for many businesses (Holguín-Veras, J Marquis, R., & Brom, M., 2012). The insights from previous research and the initial analyses in this project showed that unmanned reception of deliveries is a prerequisite for scaling up off-peak distribution.

4.1 Internet of Logistics

The first key element was to digitalize individual goods by giving them e-identities and thus allowing tracing. This was enabled by using the international logistic communication standard called "Internet of Logistics" (IoL). This industry standard was developed in a collaboration between LogTrade Technology, Ericsson, IBM, and many more. The purpose was to find a way to break data silos and provide easy and secured access to a shared data platform. If everyone integrates with IoL, they don't have to integrate with each other, thus solving the data connectivity problem as described above. This data sharing platform can be used to create different applications needed for company specific services based on the common shared data.

4.2 Off-Peak pilot

The second step of the research process was to prototype a system that connected goods to the vehicle and further, to a digital lock at a restaurant. Every assignment can be tracked and its location, whether inside pallets, containers or trailers, can be defined. Shipping notes and proof of deliveries are digitized and securing the right assignments are in the right place at the right time and any possible deviation is logged - which increases the security and trust between the operators and the receivers. The key to achieving this was to use IoL as a standard communication and integration platform which enabled all different actors and data sources to connect and communicate with each other without the need to set up individual integrations. The principles as well as the technical details are described in Figure 1.

The collected data can be analysed to create different machine learning models that can look into optimising both from a complete system perspective but also look deeper into a more efficient and time-saving route management and vehicle run-time.

A PO is received in the PS creating a Trade unit digital identity (TU) and a transport instruction (TI) in the IOL via an API	An association is created between the TU, the TI, and the assets (e.g. IOT sensors, vehicle) that will be used for this shipment	During the journey all assets independently stream their position and status through the IOL.	At the destination the driver get an onetime encrypted key if the data show that the right goods is at the right destination at the right time	The driver marks the TU as delivered and leaves, receiving a notification that the facility is locked and secured.

Figure 1: The process from receiving a Purchase Order (PO) in the planning system (PS) to completing the delivering and securing the facility is described in the picture.

The final step was to test the concept in real logistics operations in HAVIs' delivery system to evaluate the functionality in real life. HAVI delivered off-peak (22.00 – 06.00) to 4 restaurants in the Stockholm City area during a time period of 1+1 month. The tests were successful and showed that the concept works and that it can be used in scale. However, during the implementation of unmanned deliveries, inefficiencies and obstacles became evident. Although the vehicle is silent, there is still a risk of noise from the handling equipment and accidental slamming of doors etc. The off-loading of the truck into the restaurant took between 50 to 80 minutes during the first weeks, as the drivers were uncertain about the process and also there was insufficient communication between the drivers and the restaurants about where to put the goods. The restaurant had not prepared sufficient space in the fridges, so the drivers needed to reorganise goods to find space for the goods. There were also physical obstructions e.g., pallets and garbage cans that needed to be removed. When the drivers knew exactly where to place the goods, the off-loading time was reduced to about 30 minutes. The drivers were very pleased to work night-time as they felt less stress. For safety reasons, HAVI used two people for the off-peak delivery. This is a cost that is necessary but not justified for serving only 4 restaurants with off-peak solutions. However, initial calculations of the business model indicate that for a larger delivery system with more restaurants and delivery points, this investment in security for the drivers and the goods is justified.

The results showed that the delivery time savings were at least 30 percent (some weeks even up to 40 percent), which confirms the results from previous tests. The use of BEVs eliminates emissions to air in the city, except for particles from tyres and road usage. The recipients were also pleased with the system as they did not have to unpack the goods in the morning when there were customers in the restaurant. They could instead focus on giving them their full attention and good service. Another key finding of the pilot is that it can be used to further optimize route planning in order to increase the number of shipments.

5 Analysis

An additional step in the off-peak pilot is to evaluate the strengths and challenges of the current solution based on pre-requisites for data sharing. In Table 1 below we map the data sharing factors towards the current off-peak set-up. The mapping clearly shows that all factors have been addressed within the pilot project. However, there still remain some challenges, mainly concerning physical security and business value. Compatibility with pre-existing IT-systems (i.e. IT legacy) is a factor that should have been addressed early in the pilot, to try to prevent additional workarounds.

Table 1: Mapping of strengths and challenges for the data sharing within the pilot project.

Factors	**Issues**
Data	- Exists, incl. e.g., shipping notes - Shared through secure IoL communication standard for data interoperability - Is stored and can be used for analytics to further develop the business case
Business value	- Incentives for supplier and carrier to decrease congestion and be able to sell "green deliveries". Also incentives for receivers as they could reduce the number of man hours at the restaurants as goods would be delivered inside by the carriers. - Still challenges with silent handling of material, driver safety issues and finding values and thus incentives for all involved stakeholders
Regulatory foundation	- Based on business-to-business contracts - Temporarily permits for night time deliveries had to be requested and requires silent delivery - Involving security service to make sure that security fulfils insurance requirements - Data ownership structure setup between supplier, carrier and recipient.
Trust	- Existing stakeholder relationships since many years - Clear data ownership as shipper and carrier were the same company - Smart lock solution and logs increases trust
Infrastructure	- Data exchange, logging, and analysis were done through Logtrade IoL platform. - But parts of pre-existing IT-system not compatible with API:s, had to build work around solution - Has to equip the facilities with digital locks and additional security systems
Security	- The goods, trucks, and drivers each have unique authentication through different API sources. - One-time encrypted digital smart lock solutions, as well as logging of all event provides secure IT-solution - Driver and goods safety needs to be further addressed
Meta data	- Using API:s for data transfer with an agreed content and form
Skills	- Combining traditional delivery with IT competence, competence on digital locks and security service. - Recurrent training sessions for all parties involved.

Within the HITS project, we have shown that unmanned reception of off-peak deliveries is possible in bilateral business-to-business relations. We have also explored the prerequisites for data sharing in this context, as data sharing is a necessity for the off-peak deliveries. One area that we want to further explore is if, and how, data sharing can help enhance consolidated off-peak deliveries from several retailers to multiple recipients in a city.

6 Conclusions

The successful test with unmanned off-peak deliveries is an important step toward realizing a sustainable urban distribution system and it confirms previous research that the transport efficiency (number of deliveries per hour) can be enhanced by about 30 percent. The main contribution is that this can be achieved without high labour cost on the receiver side. It can be implemented based on technologies and services that already exist. The key success factor has to do with the data sharing model and how mature and structured the data behind those models are.

The focus needs to be a system perspective rather than on individual data systems. Other factors that play important roles are the willingness to apply data-driven decision making trust between the different actors within a supply chain. We can also see that the speed at which these types of software-based services are being released into the market forces the regulatory actors to adapt to new ways and should ultimately work side by side with the suppliers/carriers to make the move towards more efficient ways of getting goods in and out of urban areas.

However, there are still many obstacles to overcome before unmanned off-peak deliveries can be implemented on a large scale. An important issue is to further update the regulatory policy issues that today hinder large-scale off-peak distribution with BEVs. The new electric battery trucks can, especially if equipped with geofence technology, open many more opportunities for safe and sustainable urban distribution opportunities. This way of connecting specific goods to deliveries creates possibilities to do more accurate CO_2 calculations on the individual deliveries. We also see a need to further investigate security issues for personnel working at night-time, business models and whether there are cost savings to be made in the system to understand how upscaling can be done. This implies investigating if, e.g., different suitable distribution routes or selection of cargo categories offer better profit margins than others. We need to understand how a transformation from today's test operations to a large-scale introduction can be implemented where the values and value streams of different actors can be analysed so that a realistic implementation plan can be set over time.

7 Acknowledgements

The HITS project is co-financed by the HITS industrial partners and the FFI program (Vehicle Strategic, Research and Innovation), which is a collaboration between the Swedish governmental agencies, Vinnova, Swedish Transport Administration, Swedish Energy Agency and the automotive industry. The data sharing research presented here is financially supported by the Swedish Foundation for Strategic Research.

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